
I-40 CORRIDOR PROFILE STUDY

I-17 TO ARIZONA/NEW MEXICO BORDER

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Draft Working Paper 5: Strategic Solutions

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PREPARED FOR:

Arizona Department of Transportation



PREPARED BY:



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LIST OF ABBREVIATIONS

| Abbreviation | Name |
|--------------|--------------------------------------|
| AADT | Annual Average Daily Traffic |
| ADOT | Arizona Department of Transportation |
| BCA | Benefit-Cost Analysis |
| CCTV | Closed Circuit Television |
| CS | Candidate Solution |
| DMS | Dynamic Message Sign |
| EB | Eastbound |
| FY | Fiscal Year |
| I-40 | Interstate 40 |
| I-17 | Interstate 17 |
| LCCA | Life Cycle Cost Analysis |
| MP | Milepost |
| MP | Multi-Modal Planning Division |
| OP | Overpass |
| P2P | Planning to Programming |
| PTI | Planning Time Index |
| RWIS | Roadside Weather Information System |

| Abbreviation | Name |
|--------------|---------------------|
| SR | State Route |
| TI | Traffic Interchange |
| UP | Underpass |
| WB | Westbound |
| WIM | Weigh-in-motion |

1.1 Corridor Study Purpose

ADOT has instituted a new corridor planning approach to develop strategies and tools that incorporate life-cycle cost analysis and risk assessment to measure system performance. This Corridor Profile Study will follow the new process established by previous corridor profile studies for I-17, I-19 and I-40, to:

- Inventory past improvement recommendations.
- Assess the existing performance based on quantifiable performance measures.
- Propose various solutions to improve corridor performance.
- Identify specific solutions that can provide quantifiable benefits in relation to the performance measures.

1.2 Corridor Study Goals and Objectives

The objective of this study is to identify a recommended set of potential strategic solutions for consideration in future construction programs, derived from a transparent, defensible, logical, and replicable process. The I-40 Corridor Profile Study will define solutions and improvements for I-40 that can be evaluated and ranked to determine which investments offer the greatest benefit to the corridor in terms of enhancing performance.

The following goals have been identified as the outcome of this study:

- Link project decision-making and investments on key corridors to strategic goals
- Match solutions with deficiencies in measured performance
- Prioritize improvements that cost-effectively preserve, modernize, and expand transportation infrastructure

1.3 Working Paper 5 Overview

The objective of Working Paper #5 is to document the development of strategic solutions derived from a performance-based needs assessment for the I-40 corridor. Corridor needs (Working Paper #4) were defined through a review of the difference in baseline corridor performance.

1.4 Corridor Overview

The I-40 corridor is a major east-west transcontinental interstate highway that connects the east coast (North Carolina) to the west coast (California). I-40 is a major transportation artery route for freight as well as passenger vehicular traffic, connecting major metropolitan cities in the south-western United States. I-40 is also the primary transportation route connecting the Phoenix metropolitan area to central and north-eastern parts of the country. I-40, together with I-17, plays a key role in the transportation infrastructure of northern Arizona, contributing to its economic success.

I-40 provides the most direct and fastest link between Flagstaff (and Grand Canyon National Park), central and north-eastern United States to the east, and major Californian Cities to the west (Figure 1). I-40 provides a principal road link for freight traffic from the ports in California. This study builds on earlier planning efforts in developing and applying a performance-based process for prioritizing improvements to meet present and future needs in the corridor.

1.5 Study Location and Corridor Segments

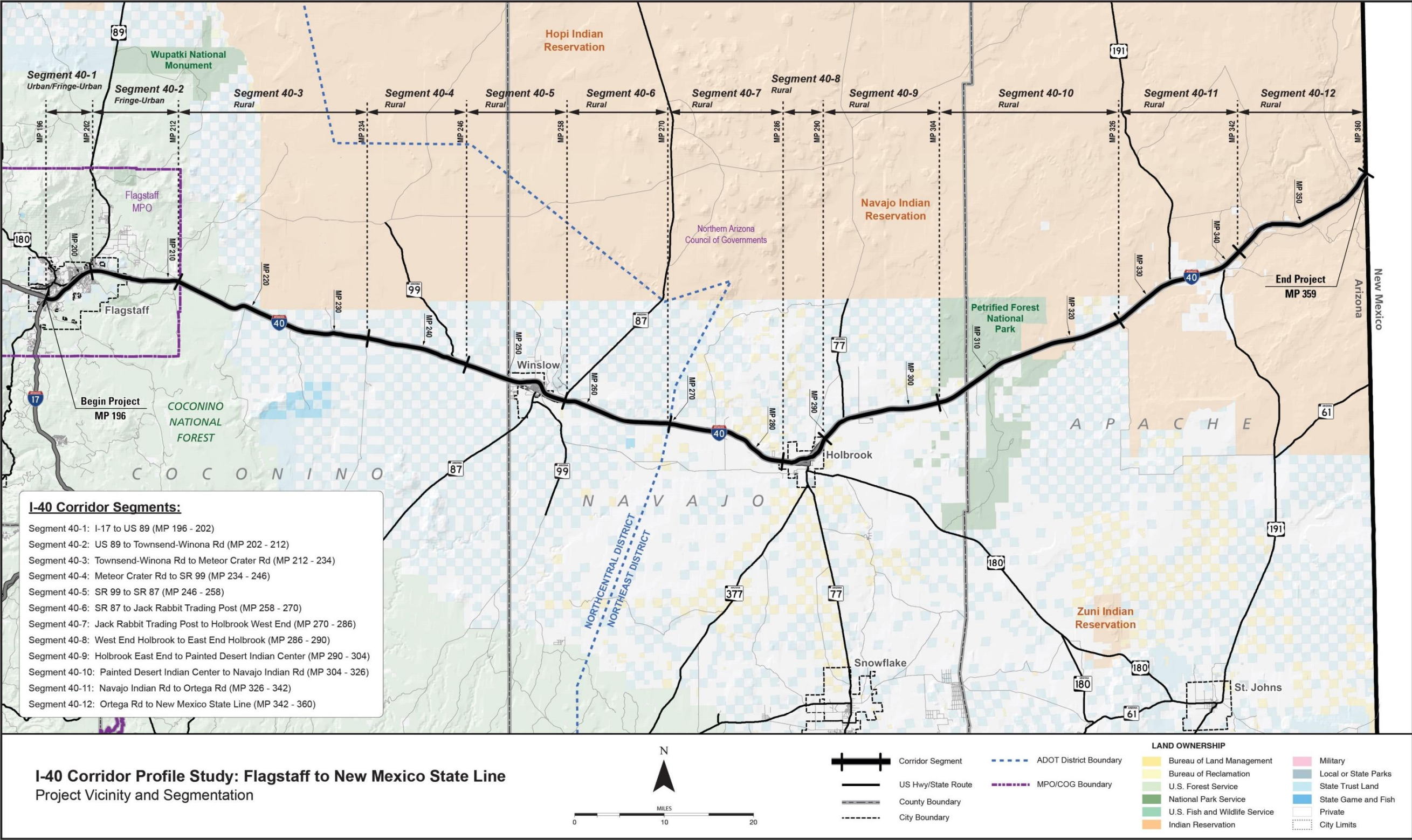
The I-40 corridor is being studied in two separate Corridor Profile Studies. One study extends from California to I-17 and this study extends from I-17 to New Mexico. For the purposes of this Corridor Profile Study, the portion from I-17 to New Mexico will be referred to as I-40 East.

The I-40 East corridor is 164 miles long, from I-17 (MP 196.0) to Arizona/New Mexico State Line (MP 360.0). The corridor has been divided into 12 distinct segments based on regionally significant intersecting routes, changes in topography, or natural or man-made landmarks along the corridor. The shortest segment is four miles long and the longest, a little over twenty-two miles. Corridor Segments have been described in **Table 1** below, and shown on a map in **Figure 2**.

Table 1: Corridor Segments and Descriptions

| Corridor Segments | | | | | | | |
|-------------------|--|----------|--------|----------------|------------|-----------------|--|
| Seg # | Begin/End Description | Begin MP | End MP | Length (miles) | Thru Lanes | 2014 AADT (vpd) | Description |
| 40-1 | I-17 to US 89 | 196 | 202 | 6 | 4 | 37,684 | This segment is generally urban/fringe-urban in nature, includes three interchanges, and is within the urbanized limits of the Flagstaff Metropolitan Area in Coconino County. |
| 40-2 | US 89 to Townsend-Winona Road | 202 | 212 | 10 | 4 | 19,257 | This segment is urban-fringe in nature, includes three interchanges, and is within Coconino County. |
| 40-3 | Townsend-Winona Road to Meteor Crater Road | 212 | 234 | 22 | 4 | 15,468 | This segment is generally rural in nature, includes four interchanges, and is within Coconino County. |
| 40-4 | Meteor Crater Road to SR 99 | 234 | 246 | 12 | 4 | 15,067 | This segment is rural in nature, includes two interchanges, and within Coconino County. |
| 40-5 | SR 99 to SR 87 | 246 | 258 | 12 | 4 | 15,422 | This segment is rural in nature, includes four interchanges, and spans Coconino and Navajo Counties. This segment passes through Winslow. |
| 40-6 | SR 87 to Jack Rabbit Trading Post | 258 | 270 | 12 | 4 | 14,604 | This segment is rural in nature, includes two interchanges, and is located within Navajo County. |
| 40-7 | Jack Rabbit Trading Post to Holbrook West End | 270 | 286 | 16 | 4 | 14,916 | This segment is rural in nature, includes four interchanges, and is located within Navajo County. |
| 40-8 | Holbrook West End to Holbrook East End | 286 | 290 | 4 | 4 | 14,124 | This segment is rural in nature, includes three interchanges, and is located within Navajo County. This segment passes through Holbrook. |
| 40-9 | Holbrook East End to Painted Desert Indian Center | 290 | 304 | 14 | 4 | 16,674 | This segment is rural in nature, includes four interchanges, and is located within Navajo County. |
| 40-10 | Painted Desert Indian Center to Navajo Indian Road | 304 | 326 | 22 | 4 | 15,519 | This segment is rural in nature, includes three interchanges, and spans Navajo and Apache Counties. |
| 40-11 | Navajo Indian Road to Ortega Road | 326 | 342 | 16 | 4 | 14,719 | This segment is rural in nature, includes three interchanges, and is located within Apache County. |
| 40-12 | Ortega Road to New Mexico State Line | 342 | 360 | 18 | 4 | 15,580 | This segment is rural in nature, includes seven interchanges, and is located within Apache County. |

Figure 2: Study Area/Segmentation Map



2.0 SUMMARY OF CORRIDOR NEEDS

2.1 Summary of Needs

Working Paper #4 documented the framework for the performance-based needs assessment process and the results for the I-40 East corridor. The needs in each performance area were classified as either None, Low, Medium, or High based on how well each segment performed in the existing performance analysis conducted in Working Paper #2. The needs for each segment were combined to numerically estimate the average level of need for each segment of the corridor.

During the Corridor Vision process for I-40 East (Working Paper #3), the Mobility, Safety and Freight Performance Areas were identified as Emphasis Areas, reflecting the future vision of the corridor as a significant facility for the movement of international goods. Therefore, a weighting factor of 1.50 was applied to those needs during the calculation process in order to ensure appropriate attention to the developing commercial route.

The needs for the I-40 East corridor are summarized below.

Pavement Performance Area

- Pavement failure hot spots were identified on 4 miles of eastbound I-40 East and 1 mile of westbound I-40 East spread throughout the corridor.
- The eastbound direction of I-40 East appears to have a higher level of performance need which may warrant consideration of alternative treatments on the eastbound roadway.
- A high level of historical investment has occurred on approximately 108 miles (66% of centerline miles) of the corridor (MP 196-212, MP 246-304 and MP 326-360) which may warrant further investigation or alternative solutions.

Bridge Performance Area

- Bridge Needs were identified at 43 of the 112 bridges (38%).
- 16 bridges have current ratings of one 5.
- 14 bridges have current ratings of multiple 5's.
- 6 bridges have current ratings of 4 or less.
- 30 bridges have current deck ratings of 5 or less.
- 20 bridges have potential historical rating issues which may be candidates for life-cycle cost analysis to evaluate alternative solutions.

Mobility Performance Area

- Future (2035) travel demand is anticipated to exceed capacity on approximately 4% of corridor, generally in Flagstaff near the I-17 System Interchange.
- A higher than average number of closures due to accidents, incidents, obstructions, or hazards occur from MP 196 to 258 primarily due to weather.

- The lowest trip reliability on corridor is along eastbound I-40 between MP 234 and 246. This segment coincides with closures that may also be due to weather.

Safety Performance Area

- Safety Needs were identified on 150 miles (92%) of the corridor.
- The highest levels of need have been identified from MP 196 to 234 and from MP 258 to 270.
- Approximately 70% of the crashes along the corridor were Single Vehicle crashes, and 52% involved an overturning vehicle with 43% involves a first unit event of ran off the road (left).
- Approximately 21% of the crashes involved under the influence of drugs or alcohol.
- MP 196-202 and MP 246-258 crashes involved a higher percentage of pedestrian and pedalcyclist crashes than similar operating environments.
- Crash hot spots near MP 198 to 199 westbound and 210 to 212 eastbound may be weather and/or lighting related.

Freight Performance Area

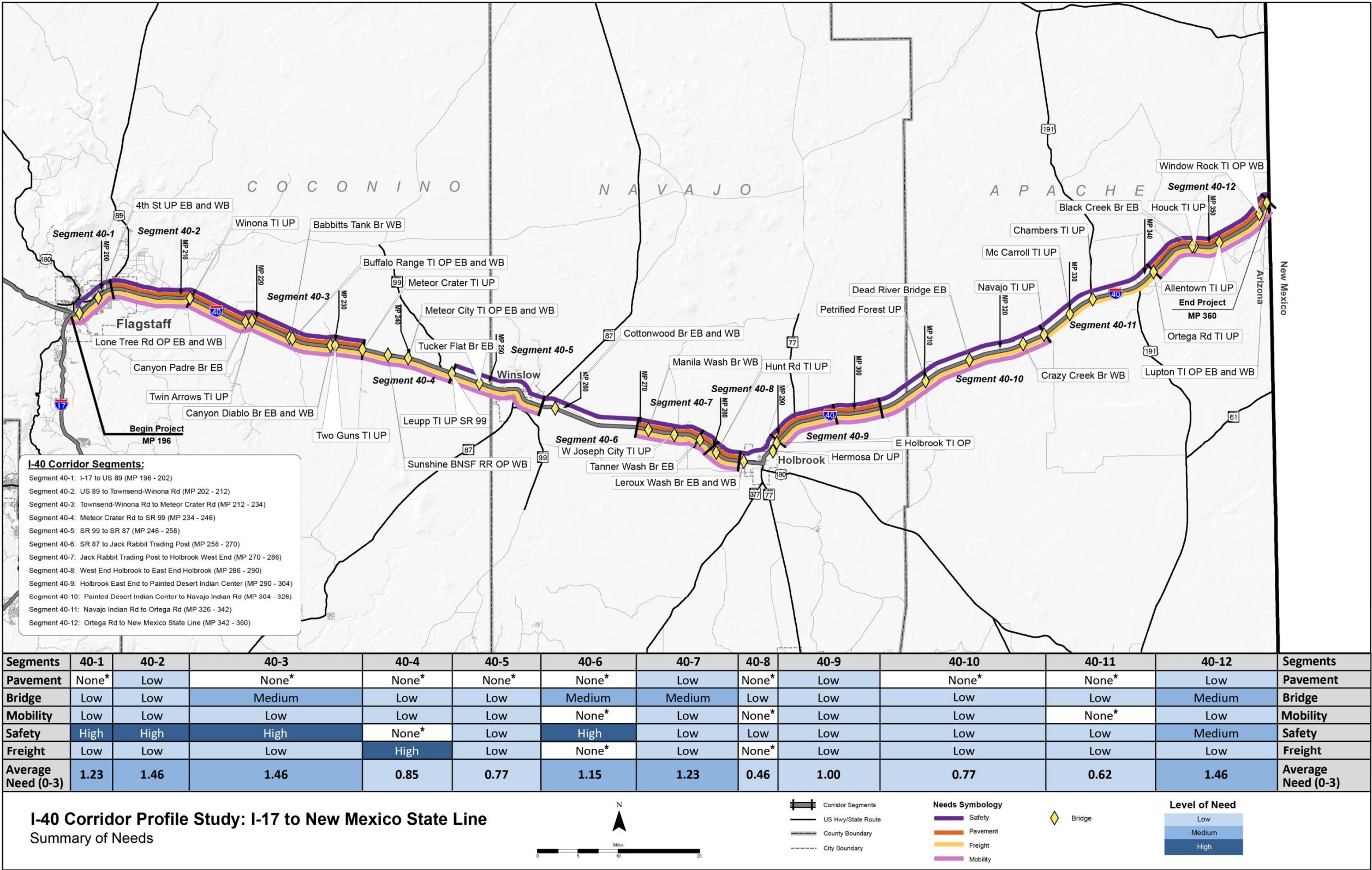
- The highest level of need was identified from MP 234 to 246, this segment was identified to have closure and PTI issues which maybe weather related. ADOT Districts confirmed that this segment of roadway have been closed multiple times due to wind.
- A higher than average number of closures due to accidents, incidents, obstructions, or hazards occurs from MP 196 to 258 primarily due to weather.

Figure 3: Summary of Needs which shows all needs identified in the assessment, ranging from None to High.

2.2 Strategic Investment Areas

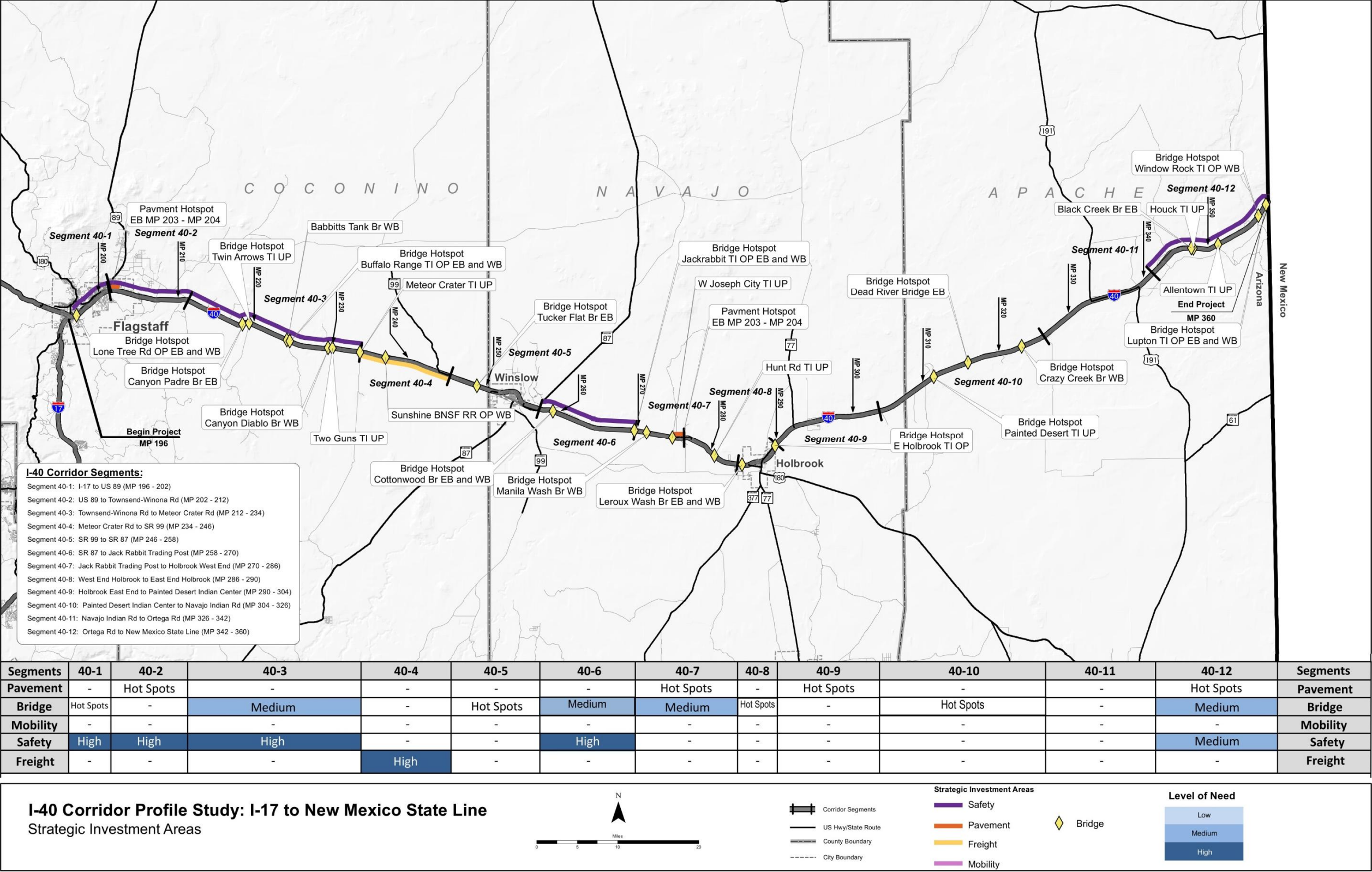
The principal objective of the corridor profile study is to identify strategic solutions (investments) that are performance-based to ensure that available funding resources are used to maximize the performance of the State's key transportation corridors. One of the first steps in the development of strategic solutions is to identify areas of elevated levels of need (Medium or High). Addressing areas of Medium or High need will have the greatest effect on the corridor performance and are the focus of the strategic solutions. Segments with Medium or High needs and specific locations of hot spots are considered candidates for strategic solutions. Segments with lower levels of need or without identified hot spots are not considered candidates for strategic investment and are expected to be addressed through other ADOT programming processes. The areas of the I-40 East corridor identified for potential strategic investments are shown in **Figure 4**.

Figure 3: Summary of Needs



*A segment need rating of 'None' does not indicate a lack of needed improvements; rather, it indicates that the segment performance score exceeds the established performance thresholds and strategic solutions for that segment will not be developed as part of this study.

Figure 4: Strategic Investment Areas



3.0 STRATEGIC INVESTMENT AREA SCREENING

This section examines qualifying strategic needs and determines if the needs in those locations require action. **Table 2** notes if each potential strategic location will advance to solution set development, and if not, the reason for screening that location out of the solution development process. Locations advancing to solutions development are marked with Yes (Y); locations not advancing are marked with No (N) and highlighted.

In some cases, elevated needs do not advance to solution development and are screened out from further consideration because they have been or will be addressed through other measures, including:

- A project has already been programmed to address the need.
- The need is a result of a pavement or bridge hot spot that does not show historical rating or investment issues. These hot spots will likely be addressed through other ADOT programming means.
- A bridge is not a hot spot but is located within a segment with a Medium or High level of need. This bridge will likely be addressed through current ADOT bridge maintenance and preservation programming processes.
- The need is determined to be non-actionable (cannot be addressed through an ADOT project).
- The conditions/characteristics of the location have changed since the performance data was collected that was used to identify the need.

The remainder of the study focuses on developing appropriate solutions for the selected strategic locations. The screening table provides specific information about the needs in each segment considered for strategic investment. The table identifies the elevated needs - either Medium or High segment needs or segments without a Medium or High level of need that have a hot spot.

Each area of need has been assigned a Location Number to help document and track specific locations that are being considered for strategic investment throughout this process.

Table 2: Strategic Investment Area Screening

| Segment | Level of Strategic Need | | | | | Location # | Type | Need Description | Advance (Y/N) | Screening Description |
|--------------------|-------------------------|----------|----------|--------|---------|------------|----------|--|---------------|---|
| | Pavement | Bridge | Mobility | Safety | Freight | | | | | |
| 40-1 MP 196-202 | | Hot Spot | | High | | L1 | Bridge | Lone Tree RD OP EB has current deck and superstructure ratings of 5 with historical concerns | Y | |
| | | | | | | L2 | Bridge | Lone Tree RD OP WB has current deck and superstructure ratings of 5 with historical concerns | Y | |
| | | | | | | L3 | Safety | Crash trends show overturning vehicle (38%), collision with pedestrian (31%), and head on (8%) crashes. Of these, dark-unlighted condition (69%), under the influence of drugs or alcohol (46%). Hot Spot WB 198-199 | Y | |
| 40-2 MP 202-212 | Hot Spot | | | High | | L4 | Pavement | EB MP 203-204 with high level of previous investment | Y | |
| | | | | | | L5 | Safety | Crash trends show overturning (45%), collision with a fixed object (27%), and head on (9%) crashes. Dark-unlighted conditions (64%) Ran off the Road (70%) under the influence of drugs or alcohol (27%). Hot Spot EB 210-212. | Y | |
| 40-3 MP 212-234 | | Medium | | High | | L6 | Bridge | Canyon Padre Br EB has no ratings less than 6 with historical concerns | N | Recent project replaced deck which increased ratings. Bridge does have historical concerns but does not meet criteria for strategic investment since low ratings have been addressed. |
| | | | | | | L7 | Bridge | Twin Arrows TI UP has current deck rating of 4 with historical concerns | N | Bridge replacement programmed in FY 16. |
| | | | | | | L8 | Bridge | Babbitts Tank Br WB has current deck and superstructure ratings of 5 without historical concerns | N | Bridge does not meet criteria for historical review, therefore not considered strategic. |
| | | | | | | L9 | Bridge | Buffalo Range TI OP EB has current deck and superstructure ratings of 5 without historical concerns | N | Bridge does not meet criteria for historical review, therefore not considered strategic. |
| | | | | | | L10 | Bridge | Buffalo Range TI OP WB has current deck and superstructure ratings of 5 with historical concerns | Y | |
| | | | | | | L11 | Bridge | Canyon Diablo BR WB has no ratings less than 6 with historical concerns | N | Recent project likely addressed low ratings. Bridge does have historical concerns but does not meet criteria for strategic investment since low ratings have been addressed. |
| | | | | | | L12 | Bridge | Two Guns TI UP has current deck rating of 5 without historical concerns | N | Bridge does not meet criteria for historical review, therefore not considered strategic. |
| | | | | | | L13 | Bridge | Meteor Crater TI UP has current deck rating of 5 without historical concerns | N | Bridge does not meet criteria for historical review, therefore not considered strategic. |
| | | | | | | L14 | Safety | Crash trends show collision with a fixed object (16%), head on (5%), and rear end (21%) crashes. Driver and road conditions: involved slush/ice/frost conditions (10%), Fatigued/Fell Asleep (16%). | Y | |

Legend: Strategic investment area screened out from further consideration

| Segment | Level of Strategic Need | | | | | Location # | Type | Need Description | Advance (Y/N) | Screening Description |
|--------------------|-------------------------|----------|----------|--------|---------|------------|----------|---|---------------|---|
| | Pavement | Bridge | Mobility | Safety | Freight | | | | | |
| 40-4 MP 234-246 | | | | | High | L15 | Freight | Freight Needs primarily associated with TPTI elevated | N | Elevated need due to trucks stopping at rest area, therefore not considered for strategic investment |
| 40-5 MP 246-258 | | Hot Spot | | | | L15 | Bridge | Tucker Flat Br EB has current deck and superstructure ratings of 5 without historical concerns | N | Bridge does not meet criteria for historical review, therefore not considered strategic. |
| 40-6 MP 258-270 | | Medium | | High | | L17 | Bridge | Cottonwood Br WB has current deck and substructure ratings of 5 without historical concerns | N | Bridge does not meet criteria for historical review, therefore not considered strategic. Bridge replacement programmed in FY 17. |
| | | | | | | L18 | Bridge | Cottonwood Br EB has current deck and substructure ratings of 5 without historical concerns | N | Bridge does not meet criteria for historical review, therefore not considered strategic. Bridge replacement programmed in FY 17. |
| | | | | | | L19 | Bridge | Jackrabbit TI OP EB has current deck and superstructure ratings of 5 without historical concerns | N | Bridge does not meet criteria for historical review, therefore not considered strategic. |
| | | | | | | L20 | Bridge | Jackrabbit TI OP WB has current deck and superstructure ratings of 5 without historical concerns | N | Bridge does not meet criteria for historical review, therefore not considered strategic. |
| | | | | | | L21 | Safety | Crash trends show overturning (73%), involved single vehicle (100%), run off the road (73%), and speed too fast for conditions (55%). Wet/slush conditions (18%), under the influence (18%), and restraint not used (27%) | Y | |
| 40-7 MP 270-286 | Hot Spot | Medium | | | | L22 | Pavement | WB MP 274-275 with high level of previous investment | Y | Pavement rehabilitation project is programmed in FY 20 (FY 19 in Tentative Program). Advance to evaluate rehabilitation versus replacement. |
| | | | | | | L23 | Bridge | Manila Wash Br WB has current deck and superstructure ratings of 5 without historical concerns | N | Bridge does not meet criteria for historical review, therefore not considered strategic. |
| | | | | | | L24 | Bridge | W Joseph City TI UP has no ratings less than 6 with historical concerns | N | Bridge does not have a rating of 4 or multiple ratings of 5 so it is not a hot spot; will likely be addressed by current ADOT processes |
| | | | | | | L25 | Bridge | Hunt Rd TI UP has current superstructure rating of 5 with historical concerns | N | Bridge does not have a rating of 4 or multiple ratings of 5 so it is not a hot spot; will likely be addressed by current ADOT processes |
| | | | | | | L26 | Bridge | Leroux Wash BR EB has current superstructure rating of 5 and substructure rating of 4 with historical concerns | Y | |
| | | | | | | L27 | Bridge | Leroux Wash BR WB has current substructure rating of 4 with historical concerns | Y | |
| 40-8 MP 286-290 | | Hot Spot | | | | L28 | Bridge | E Holbrook TI OP WB has current deck rating of 5, superstructure rating of 4 and substructure rating of 5 with historical concerns | Y | |

Legend: Strategic investment area screened out from further consideration

| Segment | Level of Strategic Need | | | | | Location # | Type | Need Description | Advance (Y/N) | Screening Description |
|---------------------|-------------------------|----------|----------|--------|---------|-------------------------------|----------|---|---------------|---|
| | Pavement | Bridge | Mobility | Safety | Freight | | | | | |
| | | | | | | L29 | Bridge | E Holbrook TI OP EB has current superstructure rating of 4 and substructure rating of 5 with historical concerns | Y | |
| 40-9 MP 290-304 | Hot Spot | | | | | L30 | Pavement | EB MP 302-303 with high level of previous investment | N | Pavement rehabilitation project is programmed in FY 16. |
| 40-10 MP 304-326 | Hot Spot | Hot Spot | | | | L31 | Bridge | Painted Desert TI UP has current deck and substructure ratings of 4 with historical concerns | Y | Recent project addressed low deck rating but likely did not address substructure rating. |
| | | | | | | L32 | Bridge | Dead River Br EB has current deck and superstructure ratings of 5 without historical concerns | N | Bridge does not meet criteria for historical review, therefore not considered strategic. |
| | | | | | | L33 | Bridge | Crazy Creek Br WB has current deck and superstructure ratings of 5 without historical concerns | N | Bridge does not meet criteria for historical review, therefore not considered strategic. |
| 40-11 MP 326-342 | | | | | | No Strategic Needs Identified | | | | |
| 40-12 MP 342-360 | Hot Spot | Medium | | Medium | | L34 | Pavement | EB MP 354-356 with high level of previous investment | N | Pavement rehabilitation project is programmed in FY 16 |
| | | | | | | L35 | Bridge | Black Creek Br EB has current deck rating of 5 with historical concerns | N | Bridge does not have a rating of 4 or multiple ratings of 5 so it is not a hot spot; will likely be addressed by current ADOT processes |
| | | | | | | L36 | Bridge | Houck TI UP has current deck rating of 5 without historical concerns | N | Bridge does not meet criteria for historical review, therefore not considered strategic. |
| | | | | | | L37 | Bridge | Allentown TI UP has current deck rating of 5 without historical concerns | N | Bridge does not meet criteria for historical review, therefore not considered strategic. |
| | | | | | | L38 | Bridge | Window Rock TI OP WB has current deck and superstructure ratings of 4 with historical concerns | Y | |
| | | | | | | L39 | Bridge | Lupton TI OP WB has current deck and superstructure ratings of 5 without historical concerns | N | Bridge does not meet criteria for historical review, therefore not considered strategic. |
| | | | | | | L40 | Bridge | Lupton TI OP EB has current deck and superstructure ratings of 5 without historical concerns | N | Bridge does not meet criteria for historical review, therefore not considered strategic. |
| | | | | | | L41 | Safety | Crash trends show collision with pedestrian (27%), failure to keep in proper lane (9%), and crossed center line (9%) crashes. Crashes occurred in snow (9%), at dawn (18%), and in dark-unknown lighting (27%). | Y | |

Legend: Strategic investment area screened out from further consideration

4.0 CANDIDATE SOLUTIONS

The corridor profile study identifies performance-based strategic solutions (investments) to help inform decision-making processes. This will enable ADOT to direct available funding resources to maximize the performance of the State’s key transportation corridors. The corridor profile process is designed to mesh with the P2P Link and assigns strategic solutions to one of three categories for investment:

- Preservation
- Modernization
- Expansion

Documented performance needs serve as the foundation for developing strategic solutions for corridor preservation, modernization, and expansion. Strategic solutions are intended to complement ADOT’s traditional project development processes through a performance-based analysis to identify needs in one or more of the five performance areas of Pavement, Bridge, Mobility, Safety, and Freight. Strategic solutions developed for key corridors will be considered along with other candidate projects in the ADOT programming process.

4.1 Characteristics of Strategic Solutions

For the purposes of the corridor profile process, strategic solutions include the following characteristics:

- Do not recreate or replace results from normal programming processes
- May include programs or initiatives, areas for further study, and infrastructure projects
- Address elevated levels of need (high or medium) and hot spots
- Focus on investments in Modernization projects (to optimize current infrastructure)
- Address overlapping needs
- Reduce costly repetitive maintenance
- Extend the operational life of system and delay expansion
- Leverage programmed projects that can be expanded to address other strategic elements
- Provide measureable benefit (benefit/cost ratio, risk, life-cycle cost analysis, performance system, etc.)

4.2 Strategic Solutions Types

Establishing uniform solution types enables the corridor profile process to compare proposed

solutions on and across corridors to determine the effectiveness at improving performance, including cost and risk comparisons to be undertaken in subsequent tasks. Appendix A provides a list of the preliminary solutions currently proposed for the corridor profile studies, separated into the three funding categories of Preservation, Modernization, or Expansion.

4.3 Candidate Solutions

The final step in this task is to identify candidate solutions that will be submitted for further analysis through the life cycle cost and risk analysis tasks. The project team accessed a variety of resources to identify solutions to address strategic investment areas:

- Field reviews
- Observable trends from performance analysis
- Discussions with districts
- ADOT technical groups
- Review previous reports
- National best practices
- Professional judgment

Table 3 identifies each location that has been assigned a candidate solution with a number (i.e. CS40.1, 40.2, etc.). Each candidate solution is comprised of one or more components to address the identified needs. The assigned CS numbers are linked to the location numbers to provide tracking capability back to the screening process. The locations of proposed solutions are shown in **Figure 5**.

In some cases, multiple solutions are proposed for a single location. Solutions that are proposed to address needs at the same location with alternate approaches (e.g., Option A, B, or C) are advanced to the Life-Cycle Cost and Benefit-Cost Analysis evaluation in Task 6 to provide insights into the cost effectiveness of these options so a recommended solution can be identified. In locations where only one option has been developed, the next step is to advance that solution directly to the solution evaluation process for prioritization.

Solutions that are recommended to expand or modify the scope of an already programed project are noted but are not advanced to solution evaluation and prioritization. These solutions will be directly recommended for programming.

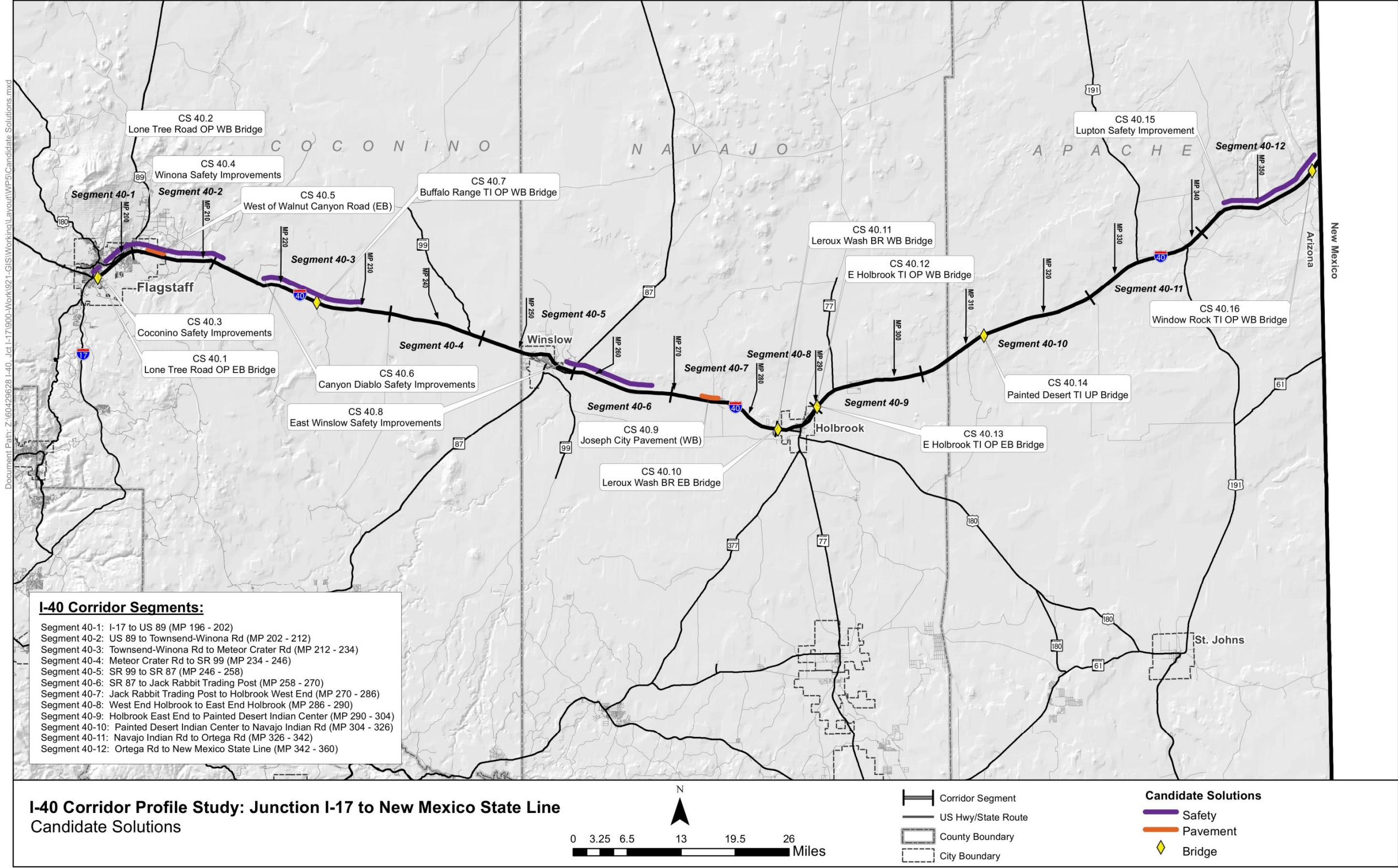
Table 3: Candidate Construction Program Solutions

| Solution # | Location # | BMP | EMP | Name | Option* | Scope | Investment Category (Preservation [P], Modernization [M], Expansion [E]) |
|------------|------------|--------|--------|-----------------------------------|---------|---|---|
| CS 40.1 | L1 | EB 196 | | Lone Tree Road OP EB Bridge | A B | Rehabilitate/repair Lone Tree Rd OP EB bridge Replace Lone Tree Rd OP EB bridge | P M |
| CS 40.2 | L2 | WB 196 | | Lone Tree Road OP WB Bridge | A B | Rehabilitate/repair Lone Tree Rd OP WB bridge Replace Lone Tree Rd OP WB bridge | P M |
| CS 40.3 | L3 | 196 | 202 | Coconino Safety Improvements | — | Install access barrier fence MP 198.5-199.5 Install rock-fall mitigation near MP 199 Construct/extend parallel entrance/exit ramps at Butler TI (MP 199) Improve skid resistance (reconstruct pavement, increase super-elevation, or mill and replace) MP 200-202 Install chevrons and curve warning signs MP 200-202 Install in-lane route pavement markings for WB I-40 at I-17 / I-40 Install lighting Enhance delineation (striping, delineators, rumble strips) Install safety edge Install Roadside Weather Information System (RWIS) Install wildlife warning system Implement variable speed limits (wireless, ground-mount) Rehabilitate/widen inside shoulder Install Closed Circuit Television (CCTV) Camera on existing DMS located at MP 199.6 EB Install new WB DMS near MP 199.6 with CCTV | M |
| CS 40.4 | L5 | 202 | 212 | Winona Safety Improvements | — | Install lighting (solar powered LED) at Walnut Canyon TI (MP 205) and Cosnino TI (MP 207) Improve skid resistance (reconstruct pavement, increase super-elevation, or mill and replace) MP 207-208 and MP 210-212 Install chevrons and curve warning signs MP 207-208 and MP 210-212 Construct/extend parallel entrance/exit ramps at Country Club TI (MP 202) and Walnut Canyon TI (MP 205) Implement variable speed limits (wireless, ground-mount) Install safety edge Install wildlife warning system Enhance delineation (striping, delineators, rumble strips) Rehabilitate/widen inside shoulder Install Roadside Weather Information System (RWIS) | M |
| CS 40.5 | L4 | EB 203 | EB 204 | West of Walnut Canyon Rd Pavement | A B | Rehabilitate/repair pavement Replace pavement | P M |
| CS 40.6 | L14 | 218 | 230 | Canyon Diablo Safety Improvements | — | Improve skid resistance (reconstruct pavement, increase super-elevation, or mill and replace) MP 218-220 and MP 229-230 Install chevrons and curve warning signs MP 218-220 and MP 229-230 Install dynamic speed feedback system near WB MP 220, WB MP 230, EB MP 218, EB MP 229 Install safety edge Enhance delineation (striping, delineators, rumble strips) Construct/extend parallel entrance/exit ramps at Twin Arrows TI (MP 220) Rehabilitate/widen inside shoulder Install Roadside Weather Information System (RWIS) near MP 222-223 Install dynamic wind warning system near MP 222-223 Install new EB DMS near MP 212.1 with CCTV Retrofit Roadside Weather Information System (RWIS) at MP 230 (Two Guns) | M |

| Solution # | Location # | BMP | EMP | Name | Option* | Scope | Investment Category (Preservation [P], Modernization [M], Expansion [E]) |
|------------|------------|--------|--------|----------------------------------|---------|---|---|
| CS 40.7 | L10 | WB 225 | | Buffalo Range TI OP WB Bridge | A B | Rehabilitate/repair Buffalo Range TI OP WB bridge Replace Buffalo Range TI OP WB bridge | P M |
| CS 40.8 | L21 | 258 | 266 | East Winslow Safety Improvements | — | Improve skid resistance (reconstruct pavement, increase super-elevation, or mill and replace) MP 258-260 Install dynamic speed feedback system near WB MP 260 and EB MP 258 Install safety edge Enhance delineation (striping, delineators, rumble strips) Install Closed Circuit Television (CCTV) Camera on existing DMS located at MP 260.2 WB | M |
| CS 40.9 | L22 | WB 274 | WB 275 | Joseph City Pavement | A B | Rehabilitate/repair pavement Replace pavement | P M |
| CS 40.10 | L26 | EB 284 | | Leroux Wash BR EB Bridge | A B | Rehabilitate/repair Leroux Wash BR EB bridge Replace Leroux Wash BR EB bridge | P M |
| CS 40.11 | L27 | WB 284 | | Leroux Wash BR WB Bridge | A B | Rehabilitate/repair Leroux Wash BR WB bridge Replace Leroux Wash BR WB bridge | P M |
| CS 40.12 | L28 | WB 290 | | E Holbrook TI OP WB Bridge | A B | Rehabilitate/repair E Holbrook TI OP WB bridge Replace E Holbrook TI OP WB bridge | P M |
| CS 40.13 | L29 | EB 290 | | E Holbrook TI OP EB Bridge | A B | Rehabilitate/repair E Holbrook TI OP EB bridge Replace E Holbrook TI OP EB bridge | P M |
| CS 40.14 | L31 | 311.5 | | Painted Desert TI UP Bridge | A B | Rehabilitate/repair Painted Desert TI UP bridge Replace Painted Desert TI UP bridge | P M |
| CS 40.15 | L41 | 345 | 360 | Lupton Safety Improvement | — | Improve skid resistance (reconstruct pavement, increase super-elevation, or mill and replace) MP 345-351 Install dynamic speed feedback system MP 345 EB and MP 351 WB Install chevrons and curve warning signs MP 345-351 Install dynamic wind warning system near MP 349/MP 350 Install Roadside Weather Information System (RWIS) near MP 349/MP 350 Enhance delineation (striping, delineators, rumble strips) Install safety edge Construct/extend parallel entrance/exit ramps at Houck TI (MP 348), Lupton TI (MP 359), and WB rest area (MP 359) | M |
| CS 40.16 | L38 | WB 358 | | Window Rock TI OP WB Bridge | A B | Rehabilitate/repair Window Rock TI OP WB bridge Replace Window Rock TI OP WB bridge | P M |

* ' — ' indicates only one solution is being proposed and no options are being considered

Figure 5: Candidate Solutions



4.4 Other Corridor Recommendations

Besides the aforementioned candidate solutions, the I-40 East corridor was evaluated to determine if other corridor-specific solutions might be appropriate. These solutions would still be strategic but would involve corridor-specific programs or initiatives rather than location-based solutions. The following corridor-specific solutions were identified for the I-40 East corridor:

- The analysis shows a high number of fatal and incapacitating injury crashes that are contributed to behavior conditions in the first three segments of the corridor. This report recommends that a Roadway Safety Analysis should be conducted on this portion of the corridor in order to better understand the high occurrence of behavior crashes and possibly designate this portion of the corridor as a “Safety Corridor”.
- Input from the North Central District and North Eastern District indicated subgrade issues in the pavement from approximately Mileposts 196 to 202 which was confirmed with a high historical investment. However, the most current data included in pavement records indicate no current need was present at the time the data was collected. This report recommends that the materials section study this section of pavement further prior to the next rehabilitation project to confirm if this section of roadway needs reconstruction.
- When recommending future projects along the I-40 East Corridor, review historical ratings and levels of investment. According to data used for this study, the following pavement and bridge locations have exhibited high historical investment (pavement) or rating fluctuation (bridge) issues:
 - Pavement MP 196-203
 - Pavement MP 204-212
 - Pavement MP 246-275
 - Pavement MP 276-304
 - Pavement MP 326-360
 - Canyon Padre Br EB (MP 218.73)
 - Twin Arrows TI UP (MP 219.53)
 - Canyon Diablo Br WB (MP 229.90)
 - Sunshine BNSF RR OP WB (MP 237.10)
 - Little Colo River Br EB/WB (MP 256.95)
 - W Joseph City TI UP (#1893) (MP 274.76)
 - Hunt Rd TI UP (MP 280.64)
 - Navajo TI UP (MP 325.92)
 - McCarroll TI UP (MP 330.00)
 - Chambers TI UP (MP 333.41)
 - Ortega Rd TI UP (MP 341.81)
 - Black Creek Br EB (MP 347.90)

In addition to location specific needs, general corridor and system wide needs were also identified through the corridor profile process. While these needs are more overarching and cannot be individually evaluated through this process, it is important to document them as well. Therefore, a recommended policies and initiatives list was developed for consideration when programming future projects not only on I-40, but across the entire state highway system where the conditions are applicable. The following list, which is in no particular order of priority, was derived from the Round 1 and Round 2 corridor profile studies.

- Install ITS conduit with all new infrastructure projects.
- Prepare strategic plans for Closed Circuit Television (CCTV) and Road Weather Information System (RWIS) locations statewide.
- Leverage power and communication at existing weigh-in-motion (WIM), dynamic messaging signs (DMS), and call box locations to expand ITS applications across the state.
- Consider solar power for lighting and ITS where applicable.
- Investigate ice formation prediction technology where applicable.
- Conduct highway safety manual evaluation for all future programmed projects.
- Develop infrastructure maintenance and preservation plans (including schedule and funding) for all pavement and bridge infrastructure replacement or expansion projects.
- Develop standardized bridge maintenance procedures so districts can do routine maintenance work.
- Review historical ratings and investment level during scoping of all new pavement and bridge projects. In areas that warrant further investigation, conduct subsurface investigations during project scoping to determine if full replacement is warranted.
- For pavement rehabilitation projects, enhance the amount/level of geotechnical investigations to address issues specific to the varying conditions along the project.
- Expand programmed and future pavement projects as necessary to include shoulders.
- Expand median cable barrier guidelines to account for safety performance.
- Install CCTV with all DMS.
- In locations with limited communications, use CCTV to provide still images rather than streaming video.
- Develop statewide program for pavement replacement
- Install additional continuous permanent count stations along strategic corridors to enhance traffic count data.

4.5 Policies and Initiatives

5.0 NEXT STEPS

Candidate solutions identified in Working Paper 5 advance to be evaluated in multiple ways including a Life-Cycle Cost or Benefit-Cost Analysis (where applicable), Risk Analysis, and a Performance Effectiveness Analysis. The methodology and approach to this analysis is briefly described below and will be documented in detail in Working Paper 6. Figure 6 illustrates the candidate solution evaluation process.

Life-Cycle Cost Analysis – All pavement and bridge candidate solutions have multiple options: rehabilitate the area of need, or fully reconstruct the issue area or structure. These options will be evaluated through a life-cycle cost analysis (LCCA) to determine the best approach for each location where a pavement or bridge solution is recommended. The LCCA could eliminate options from further consideration and identify which options should be carried forward for further evaluation.

Benefit-Cost Analysis – Any mobility, safety, or freight strategic investment area that resulted in multiple independent candidate solutions will be evaluated through a benefit-cost analysis (BCA) to determine which solutions should be eliminated or carried forward through the candidate solution evaluation process.

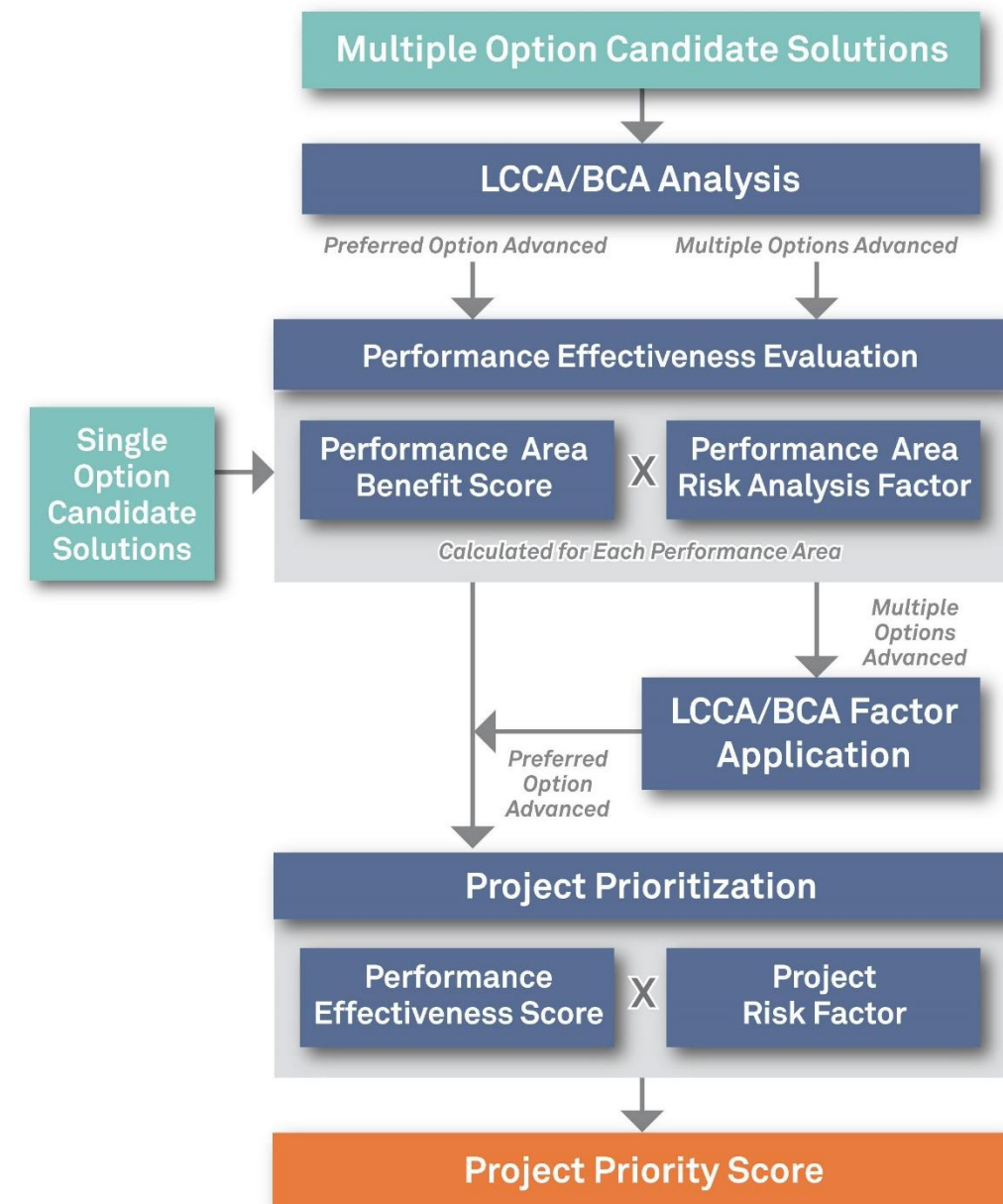
Performance Effectiveness Evaluation – After the LCCA and BCA processes are complete, all remaining candidate solutions will be evaluated based on their performance effectiveness. This process will include determining a performance effectiveness score based on how much each solution impacts the existing Performance and Needs scores for each segment. This evaluation will also include a Performance Area Risk Evaluation to help differentiate between similar solutions based on factors that are not directly addressed in the performance system.

Risk Analysis – All candidate solutions that are advanced through the Performance Effectiveness Evaluation will also be evaluated through a Risk Analysis process. This process will examine the risk of not implementing a recommended solution in terms of overall corridor performance. The results of this analysis will be combined with the Performance Effectiveness scores to determine the highest priority solutions in the corridor.

The highest ranking solutions will become recommended strategic investments for implementation and compared by ADOT to recommendations developed through other processes, such as the P2P Link process

Strategic investments are not intended to be a substitute or replacement for traditional ADOT project development processes where various ADOT technical groups and districts develop candidate projects for consideration in performance-based programming in the P2P Link process. Rather, these strategic investments are intended to complement ADOT's traditional project development processes with non-traditional projects to address performance needs in one or a combination of the five performance areas of Pavement, Bridge, Mobility, Safety, and Freight. Strategic investments developed for strategic corridors will be considered along with other candidate projects in the ADOT programming process.

Figure 6: Candidate Solution Evaluation Process



APPENDIX A:

Solution Types

PRESERVATION

REHABILITATION

- Rehabilitate Pavement
- Rehabilitate Bridge

MODERNIZATION

GEOMETRIC IMPROVEMENT

- Re-profile Roadway
- Realign Roadway
- Improve Skid Resistance

INFRASTRUCTURE IMPROVEMENT

- Reconstruct to Urban Section
- Construct Auxiliary Lanes
- Construct Climbing/Passing Lane
- Construct Reversible Lane
- Construct Entry/Exit Ramp
- Construct Turn Lanes
- Modify Entry/Exit Ramp
- Replace Pavement
- Replace Bridge
- Widen Bridge
- Install Pedestrian Bridge
- Implement Automated Bridge De-icing
- Install Wildlife Crossing
- Construct Drainage Structure

OPERATIONAL IMPROVEMENT

- Implement Variable Speed Limits
- Implement Ramp Metering
- Implement Lane Control
- Implement Shoulder Running
- Implement Signal Coordination/Adjust Timing

ROADSIDE DESIGN

- Install Guardrail
- Install Cable Barrier
- Widen Shoulder
- Rehabilitate Shoulder
- Replace Shoulder
- Install Rumble Strip
- Install Safety Edge
- Install Wildlife Fencing
- Remove Tree/Vegetation

- Install Centerline Rumble Strips
- Install Access Barrier Fence
- Install Rock-fall Mitigation

INTERSECTION IMPROVEMENT

- Construct Traffic Signal
- Improve Signal Visibility
- Install Raised Median
- Install Transverse Rumble Strips / Pavement Markings
- Single Lane Roundabout
- Double-Lane Roundabout

ROADWAY DELINEATION

- Install High-Visibility Edge Line Striping
- Install High-Visibility Delineators
- Install Raised Pavement Markers
- Install In-lane Route Pavement Markings

IMPROVED VISIBILITY

- Cut Side Slopes
- Install Lighting

DRIVER INFORMATION/WARNING

- Install Dynamic Message Sign (DMS)
- Install Dynamic Weather Warning Beacons
- Install Speed Feedback Signs
- Install Chevrons
- Install Warning Signs
- Install Wildlife Warning System

DATA COLLECTION

- Install Road Weather Information System (RWIS)
- Install Closed Circuit Television (CCTV) Camera
- Install Vehicle Detection Stations
- Install Flood Sensors

EXPANSION

WIDEN CORRIDOR

- Construct New General Purpose Lane

ALTERNATE ROUTE

- Construct Frontage Roads